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(58) Field of Search
UK CL (Edition P) G1G GPDX
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(54) Method and device for measuring rotor blade vibrations

(57) A device for measuring the rotor blade vibrations of gas turbines comprises a pressure sensor 7 which is mounted on the housing 3 of the gas turbine and projects as close as possible to the rear edge of the rotor blade stage without it being possible for the pressure sensor and the rotor blade 4 to come into contact. The pressure sensor is connected via a line (14, fig.2) to a data processing unit (13) and the signal from the pressure sensor is calibrated using a reference signal 11. The reference signal is determined only at the start of the vibration measurement and is found using strain gauges 9 connected to the rotor 2. The reference signal is transmitted by radio transmitter 12 to a fixed measuring device. The pressure signal however is measured continously throughout the operation of the turbine.

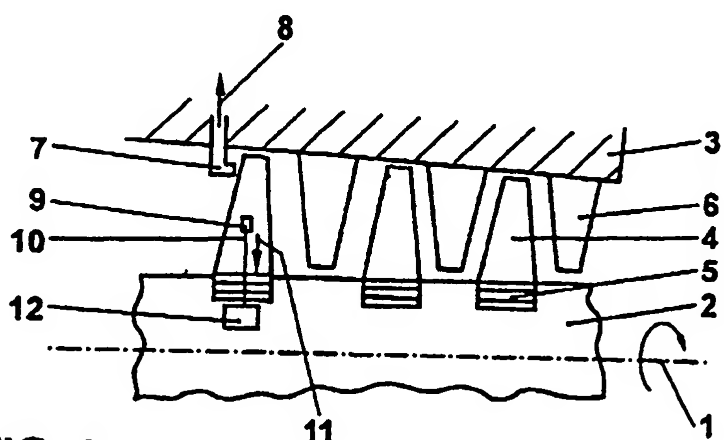

FIG. 1

GB 2 318 873 A

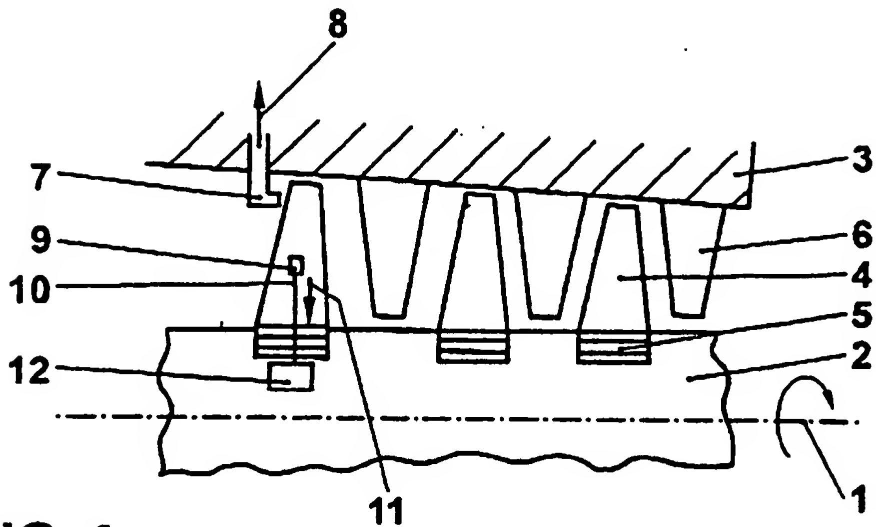

FIG. 1

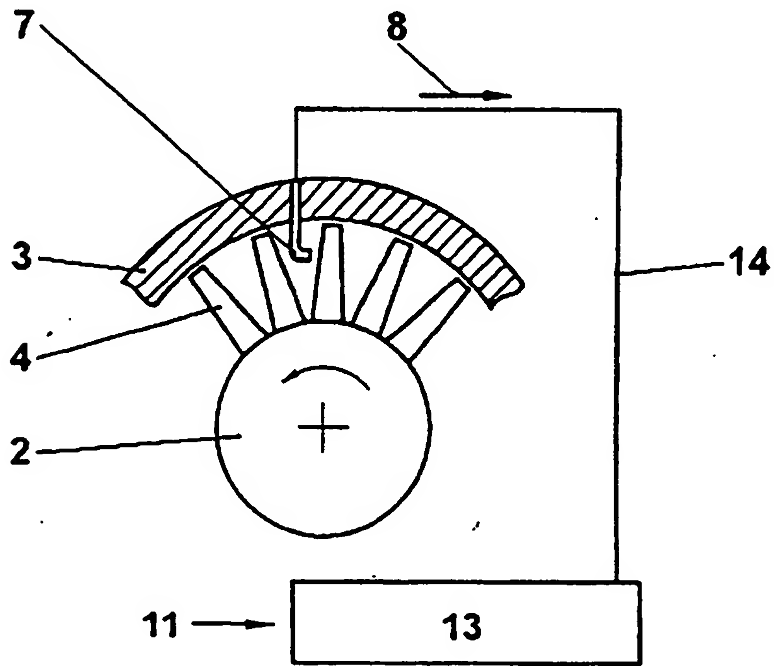

FIG. 2

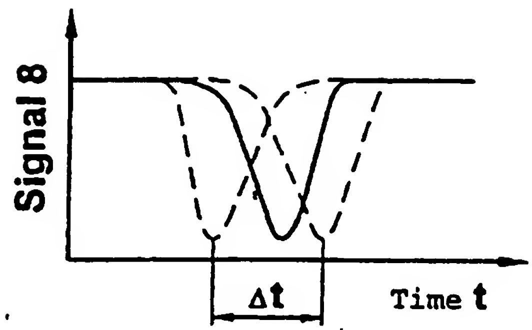

FIG. 3

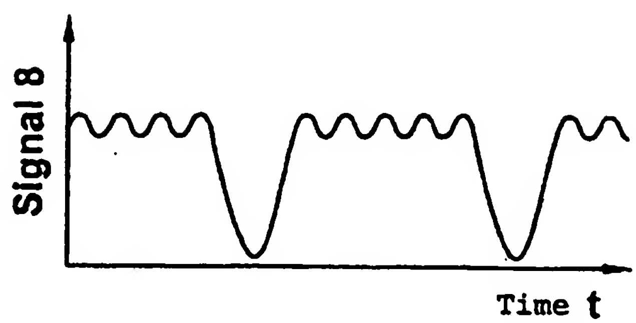

FIG. 4

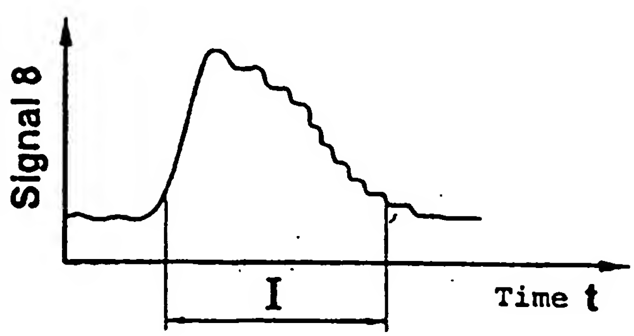

FIG. 5

TITLE OF THE INVENTION

Method and device for measuring rotor blade vibrations

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to the field of power station engineering. It relates to a method and a device for measuring the rotor blade vibrations of gas turbines.

Discussion of Background

In turbomachines, particularly the rotor blades are subjected to high static loads. Vibrations generate additional load.

Blade vibrations in fluid-flow engines can either be excited mechanically or be caused by the flow of the working medium in the machine, for example by the shocks produced in the case of partial admission, by the overtravel dents downstream of the blades of the preceding blade row or by the production of eddies at the blade as a consequence of the secondary flow (see Lueger, Lexikon der Technik, Volume 7, Deutsche Verlagsanstalt Stuttgart, 1965, page 256).

If the blade vibrations are very large and countermeasures such as, for example, load reduction, cannot be taken immediately, the blade vibrations can cause the blade to break. Blade breakages must, however, be prevented as far as possible, since the disequilibrium thereby caused can damage the machine.

In order to be able to master the blade vibrations, it is necessary to determine them by means of a suitable measurement technique.

Measurement methods are known in which the vibrations of rotor blades are measured either on the rotor or from the housing (H. Ziegler: Die Messung von Schaufelschwingungen [The measurement of blade vibrations], ABB Technik, 1994, 9, pages 31-34).

The measurement of vibrations on the rotor is performed in this case with the aid of strain gages

which are mounted on the rotor blades. Transmission of the signals from the rotor to the fixed measuring device is accomplished, for example in the case of steam turbines and gas turbines, using radio transmitters fastened to the rotor (telemetry). The disadvantages of this method consist, on the one hand, in the high outlay which stems from mounting the strain gages and lines on each blade and from laying the lines on the rotor; on the other hand, this method can be used only in the short term, e.g. for test systems. It is not suitable for continuous measurement of long duration.

The optical method for measuring blade vibrations is used in measuring blade vibrations from the housing. It permits the vibrations of all the blades of a row to be determined virtually simultaneously. The disadvantage of this prior art is that the method is relatively expensive because the measuring instrument can be operated only by a specialist, and that this method, too, can be used only in the short term because the lenses of the optical probes quickly become dirty. Furthermore, no statements can be made concerning the causes of the excitations or vibrations.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a novel method and a novel device for measuring rotor blade vibrations of gas turbines, by means of which the blade vibrations can be measured reliably over a long period during operation of the gas turbine, and at the same time statements can be made concerning the causes of the excitations to vibrations.

This is achieved according to the invention by virtue of the fact that in a method for measuring the blade vibrations of gas turbines, in which a suitable signal is measured from the housing, this signal is transmitted to a data processing unit and compared there with a reference signal, the reference

signal being determined at the rotor by means of a known method using strain gages and telemetry, the reference signal is determined only at the start of the measurement and serves as calibration parameter, that said suitable signal is measured near the rear edge of the rotor blade and is a measure of the dynamic pressure, and that said signal is measured during the entire operation of the gas turbine.

According to the invention, in the case of the device for carrying out the method a pressure sensor is mounted on the housing of the gas turbine and projects as close as possible to the rear edge of the rotor blade stage whose vibrations are to be determined, without it being possible in the operating state of the gas turbine for the pressure sensor and the rotor blade to come into contact, and which is connected by a line to a data processing unit. Preferably, the pressure sensor is arranged near the rear edge of a last rotor blade row, because the vibrations of the last blade stage are the most dangerous. The advantages of the invention consist in that it provides a simple measurement technique for determining the blade vibrations. The rotor blade vibrations can be measured without any problem during the entire operation of the gas turbine. It is possible to react quickly to excessively large vibrations, with the result that dangerous situations originating from blade vibrations do not occur in the first place. Moreover, it is possible to represent visually not only the blade vibrations, but also the fluctuations in the flow, so that the causes of the blade vibrations, and thus the excitations can be determined.

It is particularly expedient if the displacement of the overtravel position in the circumferential direction is measured. There is no relationship between the deflection of the blades which is due to the vibrations and the overtravel position.

It is, furthermore, advantageous if the turbulence level between the instances of overtravel in

the region of the natural frequency of the rotor blades is measured. This has the advantage that the primary source of the blade excitation can be detected. The source signal is essentially a pressure field which is filtered by the natural frequency of the blade. This signal can be used as a simple protective concept for blades.

Finally, the magnitude of the secondary flow is advantageously measured. At partial load, even the relatively small quantities of the secondary flow can excite the blade to vibrate.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, in which an exemplary embodiment of the invention is represented with the aid of a gas turbine and wherein:

Figure 1 shows a partial longitudinal section of the gas turbine;

Figure 2 shows a diagrammatic representation of the measuring instrument according to the invention;

Figure 3 shows a diagram for interpreting the measured signal (measuring the overtravel position);

Figure 4 shows a diagram for interpreting the measured signal (measuring the turbulence in the region of the natural frequency); and

Figure 5 shows a diagram for interpreting the measured signal (measuring the secondary flow).

Only the elements essential for understanding the invention are shown. What is not shown of the system are, for example, the, (lacuna). The flow direction of the working medium is denoted by arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, Figure 1 shows a partial longitudinal section through a gas turbine with axial through-flow. It essentially comprises a rotor 2 which rotates about an axis 1 and is surrounded by a housing 3. A plurality of rows of rotor blades 4 are pushed with their blade roots 5 into circumferential grooves in the rotor 2 and are locked there. Fixed blades 6 are fitted into the fixed housing 3 or in a blade carrier (not represented). Fixed to the housing 3 is a pressure sensor 7 which projects as close as possible to the rear edge of the last rotor blade 4. Of course, the pressure sensor 7 can also be arranged, in another exemplary embodiment, downstream of another rotor blade row. The distance between the pressure sensor 7 and the rotor blade 4 must, however, be large enough to prevent the pressure sensor 7 from being affected or damaged by vibrations of the rotor blade 4 during operation. The pressure sensor 7, which operates by means of a piezoelectric crystal, for example, measures the dynamic pressure of the flow. Said pressure is proportional to the square of the speed. The pressure sensor 7 then supplies an appropriate signal 8.

According to the invention, at the start of the vibration measurement the signal 8 must be calibrated using strain gages and telemetry using the measurement method known from the prior art. For this purpose, strain gages 9 with lines 10 which supply a reference signal 11 to a radio transmitter 12 mounted on a rotor 2 are applied to the rotor blades 4. The signals 11 are transmitted from the rotor 2 to a fixed measuring device by means of the radio transmitter 12 (telemetry). It is possible by correlating the signal 8 with the reference signal 11 to use the signal 8 for the purpose of monitoring the blade vibrations after the telemetry device has been dismounted.

Figure 2 shows a diagram of the overall measuring device according to the invention. In this case, the signal 8 generated in the pressure sensor 7 is transmitted via a line 14 into a data processing unit 13 in which the values of the calibration measurement, which must be carried out before the actual vibration measurement, are stored, transmitted and compared with the reference signals 11.

There are various possibilities for rendering useful and interpreting the signal 8, and these are represented in Figures 3 to 5. The magnitude of the signal 8 is plotted as a function of time in each of these figures.

The measurement results relating to the displacement of the overtravel position in the circumferential direction are represented in Figure 3. The deflection of the blade, which is due to the vibrations, can be deduced here from the overtravel position. The larger the time shift Δt the larger the vibration amplitudes.

This measurement technique can be applied successfully only when the blade vibrations are not dominated by frequencies which are harmonics of the rotation frequency. Blades are generally designed such that they are not excited by these harmonics. Consequently, the main purpose of the measuring system is to monitor the stochastic excitation of the blades.

Figure 4 shows results of the measurement of the turbulence levels between the instances of overtravel in the region of the natural frequency of the blades. A filter is positioned around the natural frequency of the blade, so that findings are obtained for the magnitude of the turbulence in the flow. The pressure fluctuations which are caused by the turbulence can cause blade vibrations. This method makes it possible to monitor the source of excitation instead of only looking at the after-effects.

The results of a measurement of the secondary flow are represented by way of example in Figure 5. The

wider the time interval I in which the signal 8 deviates from its basic value, the larger is the secondary flow which excites the blade to vibrate. However, this signal alone is probably not sufficient to demonstrate the level of the blade vibrations in all cases, there is a need for additional information, for example on the volume flow.

The examples shown above can also be combined with one another in order to render the resulting information on the blade vibrations particularly reliable.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

CLAIMS:

1. A method for measuring rotor blade vibrations of a gas turbine, in which a suitable signal is measured from the housing, this signal is transmitted into a data processing unit and compared there with a reference signal, the reference signal being determined at the rotor by means of a known method using strain gages and telemetry, wherein the reference signal is determined only at the start of the measurement and serves as calibration parameter, wherein said signal is measured near the rear edge of the rotor blade and is a measure of the dynamic pressure, and wherein said signal is measured during the entire operation of the gas turbine.

2. A method as claimed in claim 1, wherein the displacement of the overtravel position in the circumferential direction is measured.

3. A method as claimed in claim 1, wherein the turbulence level between the instances of overtravel in the region of the natural frequency of the rotor blades is measured

4. A method as claimed in claim 1, wherein the magnitude of the secondary flow is measured.

5. A device for carrying out the method as claimed in claim 1, wherein a pressure sensor is mounted on the housing of the gas turbine and projects as close as possible to the rear edge of the rotor blade stage whose vibrations are to be determined, without it being possible in the operating state of the gas turbine for the pressure sensor and the rotor blade to come into contact, and which is connected via a line to a data processing unit for the purpose of correlating the signal measured in the pressure sensor with a reference signal .

6. The device as claimed in claim 5, wherein the pressure sensor is arranged downstream of the last rotor blade row.

7. A method for measuring rotor blade vibrations of a gas-turbine substantially as hereinbefore described with reference to the accompanying drawings.

8. A device for measuring rotor blade vibrations of a gas-turbine substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

10

Application No:	GB 9723074.2	**Examiner:**	Catherine Schofield
Claims searched:	1-8	**Date of search:**	13 January 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G1G (GPDX)

Int Cl (Ed.6): G01M: 15/00

Other: Online:- WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	WO 82/01416 A1 (FRANKLIN INSTITUTE) - see particularly figure 1 and page 12, line 18 to page 13, line 2.	5

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.